

U.S. Serial No. 10/597,840
Amendment Dated December 16, 2008

REMARKS

Claims 1, 2 and 4-16 are pending in this application. Claims 1, 2 and 4-8 are amended, claim 3 is canceled, and new claims 9-16 are added. Claims 1, 2 and 4-8 are amended to conform to U.S. claim format, for example, by eliminating figure reference numbers.

No new matter is added to the application by this Amendment. Support for the features added to claim 1 can be found in paragraphs [0001], [0007] and [0011] of U.S. Patent Publication 2007/0158256 (hereinafter "the 256 publication") for the present application. The features added to claim 5 find support in paragraph [0026] of the 256 publication. New claims 9-16 find support in claims 9-16 in the corrected version of International Publication No. WO 2005/082499 (published on October 11, 2007) from which the present application claims priority to. For the convenience of the Patent Office, a copy of the corrected version of WO 2005/082499 is attached herewith. Additionally, the Applicants submit, for the convenience of the Patent Office, that new claims 9-16 also find support in paragraphs [0018], [0019] and [0027]-[0031] of the 256 publication.

Reconsideration of the application is respectfully requested.

I. Rejection Under 35 U.S.C. §102

Claims 1-5 were rejected under 35 U.S.C. §102(b) as allegedly being anticipated by U.S. Patent No. 5,958,243 to Lawrence et al. (hereinafter "Lawrence"). The rejection is respectfully traversed.

The Patent Office alleges that Lawrence teaches each and every feature recited in claims 1-5. Applicants respectfully disagree with this allegation.

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claim 1.

Additionally, the backwashing periods of Lawrence involve flow direction reversal of bulk fluid volumes (for example the fluid in the permeate chamber 5). Lawrence teaches away from the controller configured to operate the shut-off valve at a high frequency of claim 1 because the pressure buildup according to Lawrence requires the (bulk) fluid present in the pipe segment comprising valve 14 to be periodically put into motion which adds to the inertia of the system.

Because the features of independent claim 1 are neither taught nor suggested by Lawrence, Lawrence cannot anticipate, and would not have rendered obvious, the features specifically defined in claim 1 and its dependent claims.

For at least these reasons, claims 1, 2, 4 and 5 are patentably distinct from and/or non-obvious in view of Lawrence. Reconsideration and withdrawal of the rejections of the claims under 35 U.S.C. §102(b) are respectfully requested.

II. Rejection Under 35 U.S.C. §103

Claims 6-8 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Lawrence in view of U.S. Patent No. 4,749,476 to Storkebaum et al. (hereinafter "Storkebaum"). The rejection is respectfully traversed.

Storkebaum does not remedy the deficiencies of Lawrence as described above with respect to claim 1, from which claims 6-8 depend. Claims 7 and 8 either directly or indirectly depend from claim 6.

The Patent Office acknowledges that Lawrence fails to teach or suggest the feature, a

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retentate circulation circuit, of claims 6 (see pages 4 and 5 of the Office Action). The Patent Office introduces Storkebaum as allegedly remedying these deficiencies of Lawrence. The Patent Office alleges that it would have been obvious to provide the system disclosed by Lawrence with a retentate circulation circuit as taught by Storkebaum in order to return the retained substance to the feed supply, if desired to do so. Applicants respectfully disagree with these allegations.

As discussed with respect to claim 1, Lawrence does not teach or suggest a controller adapted to operate the shut-off valve at a high frequency as required by claim 1. Storkebaum fails to remedy the deficiencies of Lawrence because Storkebaum does not teach or suggest operating a valve at a high frequency. Thus, neither Lawrence nor Storkebaum, taken singly or in combination, teaches or suggests a controller adapted to operate the shut-off valve at a high frequency as required by claim 1.

Because these features of independent claim 1 are not taught or suggested by Lawrence and Storkebaum, taken singly or in combination, these references would not have rendered the features of claim 1 obvious to one of ordinary skill in the art.

For at least these reasons, claims 6-8 are patentable over Lawrence and Storkebaum. Thus, withdrawal of the rejection under 35 U.S.C. §103(a) is respectfully requested.

III. New Claims

Neither Lawrence nor Storkebaum, taken singly or in combination, teaches or suggests the required features of the apparatuses of new claims 9-14 or the methods of new claims 15 and 16.

For at least this reasons, new claim 9-16 are patentable over Lawrence and Storkebaum,

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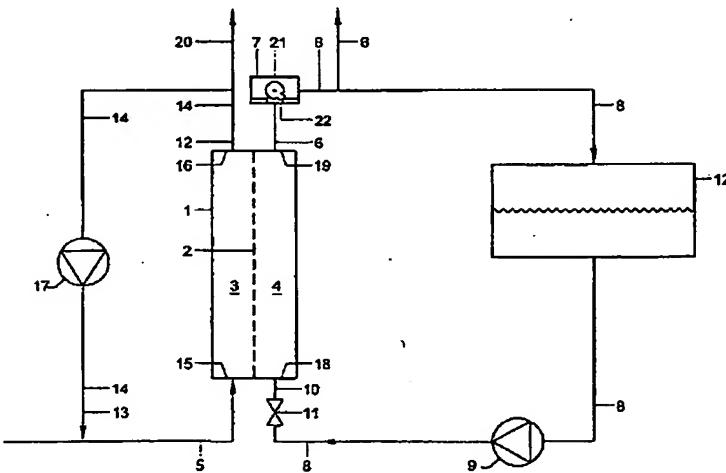
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(54) Title: APPARATUS AND METHOD FOR MICRO OR ULTRAFILTRATION



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(57) Abstract: An apparatus provided with a micro or ultrafiltration filter, wherein the filter is provided with a filter housing having a retentate side and a permeate side, wherein the retentate side and the permeate side are separated from each other by filter material, wherein a fluid supply pipe is connected to the retentate side and a permeate discharge pipe to the permeate side, wherein, in the permeate discharge pipe, a shut-off valve operable at a high frequency is provided and wherein means are connected to the permeate side for increasing the pressure in the permeate side when the said shut-off valve is closed to a value which is higher than the pressure on the retentate side.

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Title: Apparatus and method for micro or ultrafiltration

The invention relates to an apparatus provided with a micro or ultrafiltration filter, where the filter is provided with a filter housing having a retentate side and a permeate side, where the retentate side and the permeate side are separated from each other by filter material, where a 5 fluid supply pipe is connected to the retentate side and a permeate discharge pipe to the permeate side.

Such an apparatus is known from practice. Micro or ultrafiltration are filtration processes used to separate fluids on the basis of a difference in particle or molecule dimensions. For this purpose, filter material is used 10 with a pore diameter of the order of magnitude of 0.1-10 micrometer (microfiltration) or with a MWCO (molecular weight cut off) of 1 kDa to about 200 kDa (ultrafiltration). In practice, such filter material is also referred to by the term filter membrane. Examples of applications are 15 concentrating proteins in milk, removing microorganisms and clearing fruit juices and wine. Important process parameters for micro and ultrafiltration are the flux and the selectivity. The flux relates to the amount of fluid that permeates per time unit and per unit of filter material surface and is an indicator of the capacity of the process. The selectivity indicates the ratio of the concentration of two components to be separated in the permeate in 20 relation to the starting fluid and is a measure of the efficiency of the separation step.

A problem of micro and ultrafiltration is that the filter material 25 pollutes very rapidly; blocked components accumulate against and in the filter material and this adversely affects the flux and the selectivity of the process. It has already been proposed to clean the filter material by reversing the fluid flow in the filter material. In the literature, such an

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action is referred to by the term back pulsing. A description thereof is given in European patent application EP-A-0 588 348. The solution described in that publication is not suitable for high-frequency back pulsing. A high frequency is desired to keep the filter material as clean as possible. In 5 addition, the back pulse needs to take as short a time as possible to adversely affect the capacity of the filtration process as little as possible. These objects are insufficiently achieved with the apparatus described in the European application. The invention contemplates an apparatus in which these objects are achieved.

10 For this purpose, according to the invention, the apparatus of the type described in the introduction is characterized in that in that a shut-off valve operable at a high frequency is provided in the permeate discharge pipe, while means are connected to the permeate side for increasing the pressure in the permeate side when the shut-off valve is closed to a value 15 higher than the pressure on the retentate side.

20 The means for increasing the pressure need to be designed such that the pressure on the permeate side increases very fast to above the pressure prevailing in the retentate side. This is because then, in a minimal period of time, the back pulse can be effected, after which the shut-off valve can be opened again and the normal filtration process can take place again. Thus, 25 the capacity of the filtration process is hardly adversely affected.

According to a further elaboration of the invention, a very rapid pressure build-up can be obtained with an apparatus in which the shut-off valve is designed to be opened and closed periodically, with the shut-off 25 valve being kept in a closed position so long that a higher pressure is built up on the permeate side than on the retentate side, such that a reversal of the fluid flow in the filter material occurs, while the means for increasing the pressure in the permeate side are designed such that, for the rest, a reversal of flow direction of fluid in pipes of the apparatus is prevented. 30 Because there no reversal of the flow direction of fluid volumes occurs in any

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of the pipes, the slowness in the system during the building up of the hydrostatic pressure on the permeate side will be minimal.

Such an apparatus may, for instance, be realized in that the means for increasing the pressure comprise at least one permeate circulation circuit which is, on the one side, connected, by an inlet, to the permeate discharge pipe at a point downstream of the shut-off valve and, on the other side, by an outlet, to the permeate side of the filter housing, while a permeate circulation pump is provided in the permeate circulation circuit.

In a thus designed apparatus, in an opened condition of the shut-off valve, permeate is pumped around through the permeate circulation circuit. As soon as the shut-off valve is in a closed position, the pressure will increase downstream of the permeate circulation pump, resulting in the pressure in the permeate side of the filter housing increasing. When the shut-off valve remains closed long enough, the pressure on the permeate side will become higher than on the retentate side and back pulsing will occur.

By suddenly closing the shut-off valve, pressure instability in the pipe system can occur, which could result in, for instance, water shock. In order to prevent this phenomenon, according to a further elaboration, it is particularly favorable if, upstream of the outlet of the permeate circulation circuit and downstream of the permeate circulation pump, a restriction is included in order to prevent a jerky pressure build-up.

In addition, in the permeate circulation circuit, a permeate buffer tank may be included for feeding the pump during the closed condition of the shut-off valve.

According to a further elaboration of the invention, it is particularly favorable if the fluid supply pipe is connected to a first end of the retentate side of the filter housing, while a retentate circulation circuit is provided, while an inlet of the retentate circulation circuit is connected to a second end of the retentate side of the filter housing, while an outlet of the

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retentate circulation circuit is connected to the fluid supply pipe, while a retentate circulation pump is provided in the retentate circulation circuit, while the first end is opposite the second end, such that, with a switched-on retentate circulation pump, a cross-flow along the filter material occurs.

5 Such a cross-flow results in a cleaning action of the filter material which, in combination with the above-described back pulsing, results in an improved selectivity and flux of the filter material.

According to a further elaboration of the invention, it is favorable if the outlet of the permeate circulation circuit is connected to a first end of 10 the permeate side of the filter housing, while the permeate discharge pipe is connected to a second end of the permeate side of the filter housing, while the first end is opposite the second end, such that, on the permeate side of the filter housing, a cross-flow along the filter material occurs, while the cross-flow on the retentate side has the same flow direction as the cross-flow 15 on the permeate side.

It has been found that, on the retentate side, under the influence of the cross-flow prevailing there, a pressure drop prevails in the filter housing viewed in the cross-flow direction. This therefore results in the pressure on the retentate side of the filter material not being equal over the whole 20 surface of the filter material. If there is an equal pressure everywhere on the permeate side of the filter material, the result will be that the pressure drop over the filter material viewed over the surface of the filter material varies. This in turn results in the flow rate through the filter material viewed over the surface of the filter material not being equal everywhere. 25 By now ensuring that the cross-flow on the retentate side has the same flow direction as the cross-flow on the permeate side, a substantially equal pressure drop can be effected over the whole surface of the filter material.

According to a further elaboration of the invention, in opened condition of the shut-off valve, the circulation in both circulation circuits

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mentioned is such that the pressure drop is substantially equal over the whole surface of the filter material.

According to a further elaboration of the invention, more than one permeate circulation circuit can be provided for forming a corresponding number of back pulse pressure areas on the permeate side of the filter housing. This has the advantage that, in the part in the filter where more pollution occurs, back pulsing can, for instance, take place more often and/or using more volume and/or counterpressure. This has the advantage that, with severely polluting areas, the cleaning can be carried out more thoroughly and/or more regularly than in areas where the pollution is only limited.

It will be clear that the retentate circulation circuit is also connected to a retentate discharge pipe.

According to a further elaboration of the invention, it is particularly favorable when the frequency at which the shut-off valve is operable is in the range of 1-1000 Hertz. At such a frequency, an excellent selectivity can be preserved as well as an improvement of the capacity of the apparatus. Viewed in time, the shut-off valve may, for instance, be closed 2-50% and opened 50-98%.

According to a further elaboration of the invention, the shut-off valve may comprise a valve housing in which a rotating camshaft is arranged, while the cam of the camshaft forms a closure in a certain range of rotational positions and allows a free passage of permeate in other positions, the camshaft being continuously drivable. Such a shut-off valve has a simple construction. Preferably, the rotational speed of the camshaft is controllable for controlling the back-pulse frequency.

The invention further relates to a method for operating an apparatus according to the invention, where, in the filter housing, periodically at a high frequency, a higher pressure is built up on the permeate side than on the retentate side, such that a reversal of the fluid flow in the filter material

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occurs, while, for the rest, a reversal of flow direction of fluid volumes in pipes of the apparatus is prevented.

According to a further elaboration of the method according to the invention, in both the retentate and the permeate side of the filter housing, 5 a cross-flow can be maintained for a further improvement of the flux and the selectivity of the filter material and for maintaining a substantially equal pressure drop over the whole surface of the filter material.

The invention will now be explained on the basis of two exemplary embodiments with reference to the drawing, in which:

10 Fig. 1 shows a first exemplary embodiment of the apparatus according to the invention;

Fig. 2 shows a second exemplary embodiment; and

Fig. 3 shows a third exemplary embodiment.

The Figures all shows an exemplary embodiment of the apparatus 15 where the filter housing is designated by 1. In the filter housing, filter material 2 is included which is usually designed as a filter membrane in practice. The filter membrane 2 divides the filter housing into a retentate side 3 and a permeate side 4. To the retentate side 3, a fluid supply pipe 5 is connected. To the permeate side 4, a fluid discharge pipe 6 is connected. In 20 the permeate discharge pipe 6, near the filter housing 1, a shut-off valve 7 operable at a high frequency is included. Further, a permeate circulation circuit is provided which comprises a circulation pipe 8. The permeate circulation pipe 8 is connected, by an inlet, to the permeate discharge pipe 6 at a point downstream of the shut-off valve 7. An outlet of the permeate 25 circulation pipe 8 is connected to the permeate side of the filter housing 1. In the permeate circulation pipe 8, a permeate circulation pump 9 is provided. Downstream of the pump 9 and upstream of the outlet 10, a restriction 11 is included in order to prevent jerky pressure build-up. Further, in the permeate circulation pipe 8, a permeate buffer tank 12 is 30 included for feeding the permeate circulation pump 9 during the closed

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position of the shut-off valve 7. The fluid supply pipe 5 is connected to a first end 15 of the retentate side 3 of the filter housing 1. Further, a retentate circulation circuit is provided of which the inlet 12 is connected to a second end 16 of the retentate side 3 of the filter housing 1. An outlet 13 of the 5 retentate circulation circuit is connected to the fluid supply pipe 5. In the retentate circulation circuit, which comprises a retentate circulation pipe 14, a retentate circulation pump 17 is provided. The first end 15 is opposite the second end 16, such that, with a switched-on retentate circulation pump 17, a cross-flow along the filter membrane 2 occurs. The 10 outlet 10 of the permeate circulation circuit 8 is connected to a first end 18 of the permeate side of the filter housing 1. The permeate discharge pipe 6 is connected to a second end 19 of the permeate side 4 of the filter housing 1. The first end 18 is opposite the second end 19, such that, on the permeate side of the filter housing 1, a cross-flow along the filter material 2 occurs. 15 The cross-flow on the retentate side 3 has the same flow direction as the cross-flow on the permeate side 4. Here, the permeate circulation pump 9 and the retentate circulation pump 17 are preferably controlled such that, in opened condition of the shut-off valve 7, the circulation in both circulation circuits is such that the pressure drop is substantially equal over the whole 20 surface of the filter material 2. To the retentate circulation circuit 14, further, a retentate discharge pipe 20 is connected for discharging the retentate not recirculated via the recirculation pipe 14.

The shut-off valve 7 is provided with a valve housing in which a rotating camshaft 21 is arranged. A cam 22 on the camshaft 21 forms a 25 closure in a certain range of rotational positions and allows a free passage of permeate in the other positions. Preferably, the camshaft 21 is continuously drivable and the rotational speed of the camshaft 21 is controllable for controlling the back-pulse frequency.

With the exemplary embodiment shown in Fig. 1, in the filter 30 housing 1, periodically at a high frequency, a higher pressure can be built

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up on the permeate side than on the retentate side, such that a reversal of the fluid flow in the filter material 2 occurs and where, for the rest, a reversal of the flow direction of fluid volumes in the pipes of the apparatus is prevented. The result of all this is that a very high back-pulse frequency 5 can be used. By combining this high back-pulse frequency with a cross-flow on both the permeate side 4 and the retentate side 3, an excellent cleaning of the filter material or the filter membrane 2 is obtained without the capacity of the apparatus being reduced considerably as a result of the back pulsing. The selectivity and the flux remain high and the process can be 10 continued for a prolonged time.

The exemplary embodiments of Figs. 2 and 3 differ from the exemplary embodiment of Fig. 1 in that three permeate circulation circuits 8, 8', 8" are present. Each permeate circulation circuit can be provided with its own pump 9, 9', 9" as shown. Each permeate circulation pump 9, 9', 9" then produces its own back-pulse pressure. However, it is also 15 possible that only one pump is provided for all permeate circulation circuits and that the back-pulse pressures in the different circuits differ from one another in that, in each permeate circulation circuit, a different restriction 11, 11', 11" is included.

20 In the exemplary embodiment of Fig. 2, dotted lines indicate that, downstream of the permeate circulation pumps 9, 9', 9", short-circuit pipes are connected, which are each, by an outlet, connected to the permeate discharge pipe 6 downstream of the shut-off valve 7. In each of these short-circuit pipes, a shut-off valve 7', 7" needs to be present that is 25 normally closed but that can be opened when the shut-off valve 7 is closed to prevent the back pulse of the respective permeate circulation circuit. In this manner, the frequency of the back pulsing can be varied per permeate circulation circuit. For this purpose, the shut-off valves 7', 7" can be designed as pulsing shut-off valves.

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In the exemplary embodiment of Fig. 3, the permeate side 4 of the filter housing 1 is divided into three compartments 4, 4', 4". To each compartment 4, 4', 4", a permeate circulation pump 8, 8', 8" is connected at an upstream end of the compartment 4, 4', 4". Further, to each 5 compartment 4, 4', 4", a discharge pipe 6, 6', 6" is connected at a downstream end of the compartment. In each discharge pipe 6, 6', 6", a pulsing shut-off valve 7, 7', 7" is included for creating back-pulse behavior specific to the respective compartment. The shut-off valves 7, 7', 7" can be designed in the manner as described with reference to the first exemplary 10 embodiment. Both for the exemplary embodiment of Fig. 2 and that of Fig. 3, it holds true that the (pulsing) shut-off valves 7, 7', 7" can be synchronized, for instance in that one camshaft is provided which bears a cam for each shut-off valve. In this context, synchronizing is to be understood in a broad sense, in the sense that the opening and closing of the 15 various shut-off valves are geared to one another.

It is clear that the invention is not limited to the exemplary embodiment described but that various modifications are possible within the framework of the invention as defined by the claims.

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CLAIMS

1. An apparatus provided with a micro or ultrafiltration filter, wherein the filter is provided with a filter housing (1) having a retentate side (3) and a permeate side (4), wherein the retentate side and the permeate side are separated from each other by filter material (2), wherein a fluid supply pipe (5) is connected to the retentate side (3) and a permeate discharge pipe (6) to the permeate side (4), wherein, in the permeate discharge pipe (6), a shut-off valve (7) operable at a high frequency is provided and wherein means (8-11) are connected to the permeate side (4) for increasing the pressure in the permeate side (4) when the said shut-off valve (7) is closed to a value which is higher than the pressure on the retentate side (3).
5
2. An apparatus according to claim 1, wherein the shut-off valve (7) is designed to be opened and closed periodically, wherein the shut-off valve (7) is kept in a closed position so long that a higher pressure is built up on the permeate side (4) than on the retentate side (3), such that a reversal of the fluid flow in the filter material (2) occurs, wherein the means (8-11) for increasing the pressure in the permeate side (4) are designed such that, for the rest, a reversal of flow direction of fluid volumes in pipes of the apparatus is prevented.
10
3. An apparatus according to claim 1 or 2, wherein the means (8-11) for increasing the pressure comprise at least one permeate circulation circuit (8) which is, on the one side, connected, by an inlet, to the permeate discharge pipe (6) at a point downstream of the shut-off valve (7) and, on the other side, by an outlet (10), to the permeate side (4) of the filter housing (1), wherein a permeate circulation pump (9) is provided in the permeate circulation circuit.
15
4. An apparatus according to claim 3, wherein, upstream of the outlet (10) of the permeate circulation circuit (18) and downstream of the

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pump (9), a restriction (11) is included in order to prevent a jerky pressure build-up.

5. An apparatus according to claim 3 or 4, wherein, in the permeate circulation circuit (8), a permeate buffer tank (12) is provided for feeding the 5 permeate circulation pump (9) during the closed condition of the shut-off valve (7).

6. An apparatus according to any one of the preceding claims, wherein the fluid supply pipe (5) is connected to a first end (15) of the retentate side (3) of the filter housing (1), wherein a retentate circulation circuit (14) 10 is provided, wherein an inlet (12) of the retentate circulation circuit (14) is connected to a second end (16) of the retentate side (3) of the filter housing (1), wherein an outlet (13) of the retentate circulation circuit (14) is connected to the fluid supply pipe (5), wherein a retentate circulation pump (17) is provided in the retentate circulation circuit (14), wherein the 15 first end (15) is opposite the second end (16), such that, with a switched-on retentate circulation pump (17), a cross-flow along the filter material (2) occurs.

7. An apparatus according to claim 6, wherein the outlet (10) of the permeate circulation circuit is connected to a first end (18) of the permeate side (4) of the filter housing (1), wherein the permeate discharge pipe (6) is connected to a second end (19) of the permeate side (4) of the filter housing (1), wherein the first end (18) is opposite the second end (19), such that, on the permeate side (4) of the filter housing (1), a cross-flow along the filter material (2) occurs, wherein the cross-flow on the retentate side (3) 25 has the same flow direction as the cross-flow on the permeate side (4).

8. An apparatus according to claim 7, wherein, in opened condition of the said shut-off valve (7), the circulation in both said circulation circuits (8, 14) is such that the pressure drop is substantially equal over the whole surface of the filter material (2).

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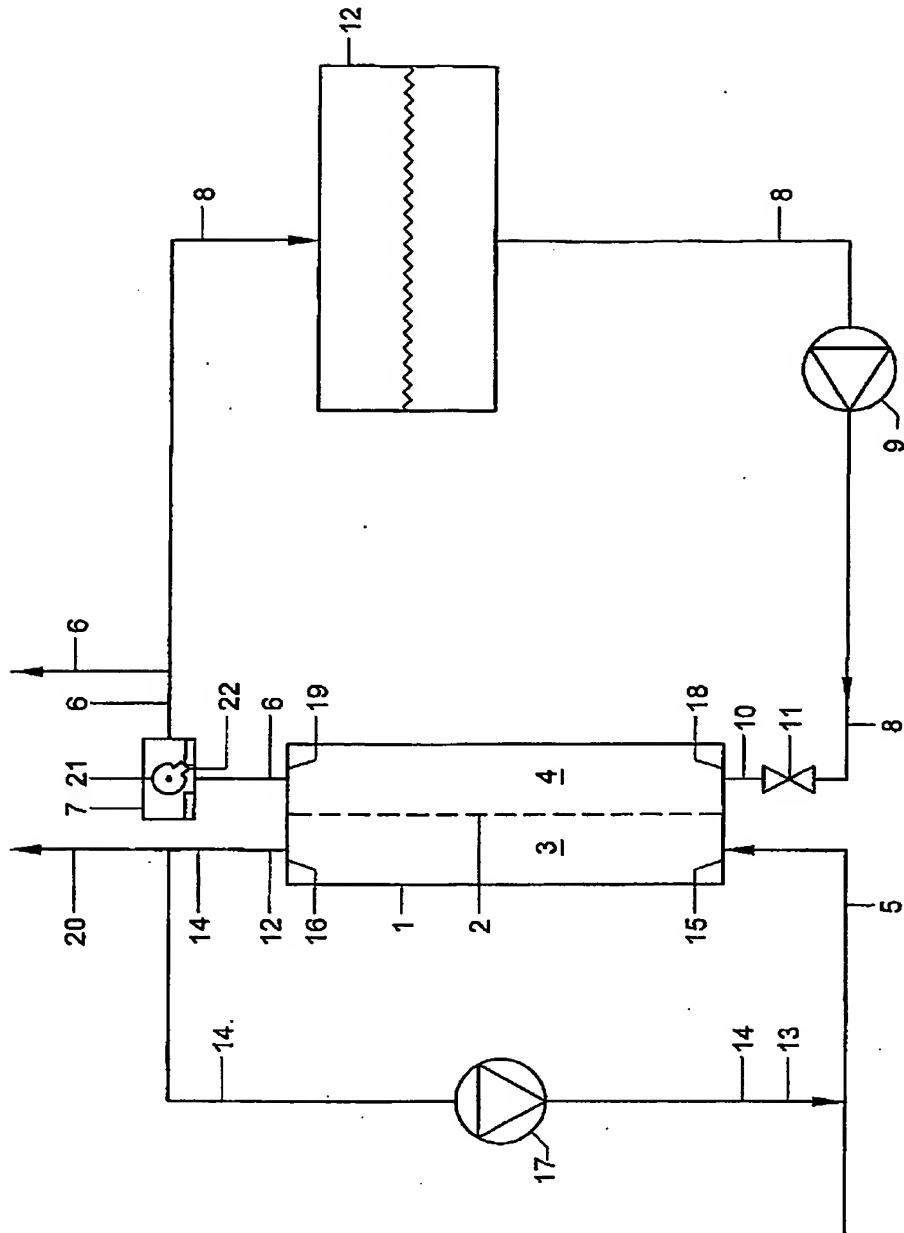
9. An apparatus according to claim 3, wherein more than one permeate circulation circuit is provided for forming a corresponding number of back pulse pressure areas on the permeate side (4) of the filter housing (1).
10. An apparatus according to any one of the preceding claims, wherein, 5 to the retentate circulation circuit (14), a retentate discharge pipe (20) is connected.
11. An apparatus according to any one of the preceding claims, wherein the frequency at which the shut-off valve is operable is in the range of 1 to 1000 Hz.
- 10 12. An apparatus according to any one of the preceding claims, wherein, in a period comprising the opened and the closed position, the shut-off valve (7) is in an opened position for 50-98% of that period and is in the closed position for 2-50% of that period.
13. An apparatus according to any one of the preceding claims, wherein 15 the shut-off valve comprises a valve housing in which a rotating camshaft is arranged, wherein the cam of the camshaft forms a closure in a certain range of rotational positions and allows a free passage of permeate in other positions, wherein the camshaft is continuously drivable.
14. An apparatus according to claim 13, wherein the rotational speed of 20 the camshaft is controllable for controlling the back-pulse frequency.
15. A method for operating an apparatus according to any one of the preceding claims, wherein, in the filter housing, periodically at high frequency, a higher pressure is built up on the permeate side than on the retentate side, such that a reversal of the fluid flow in the filter material 25 occurs, wherein, for the rest, a reversal of flow direction of fluid volumes in pipes is prevented.
16. A method according to claim 15, wherein on both the retentate and the permeate side of the filter housing, a cross-flow is maintained.

SUBSTITUTE SHEET (RULE 26)

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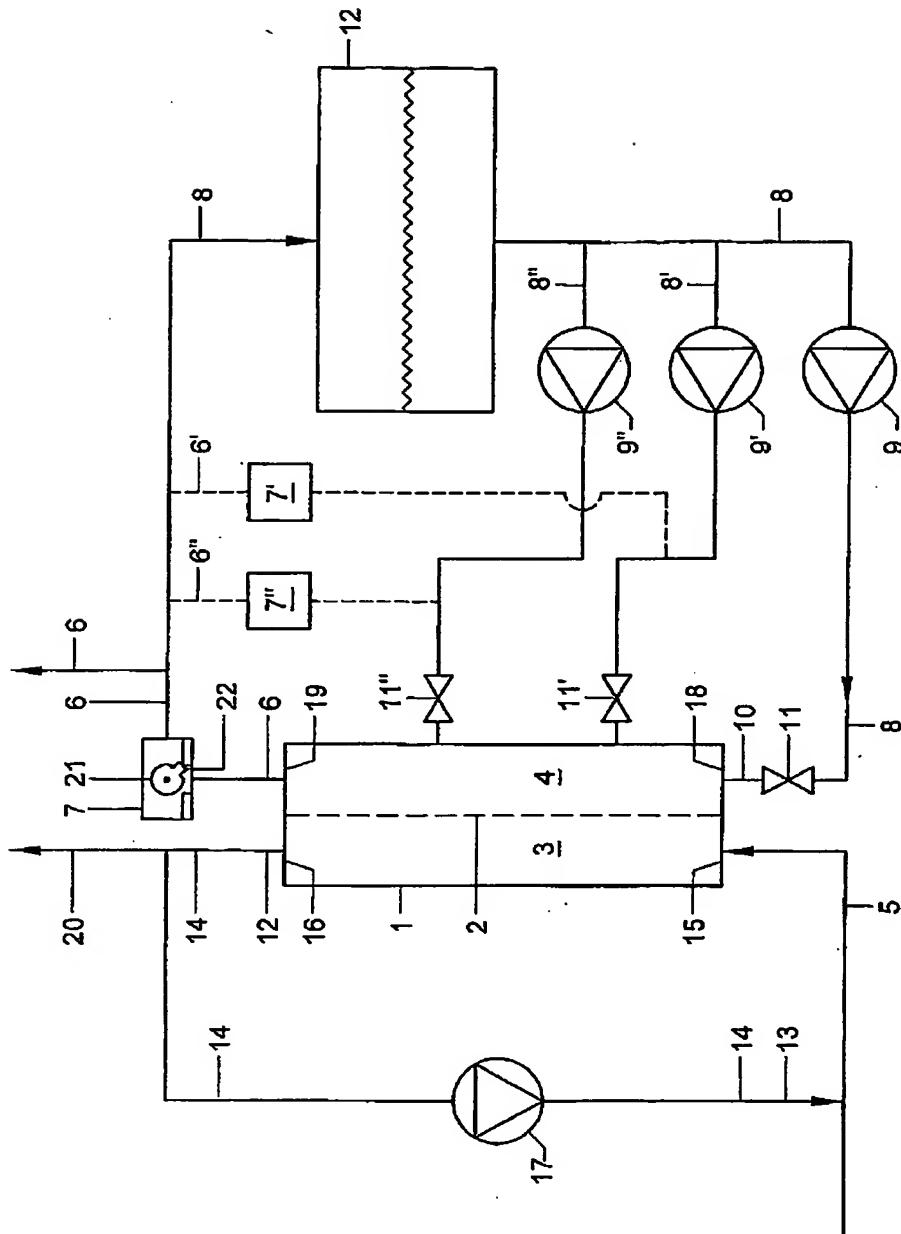


Fig. 2

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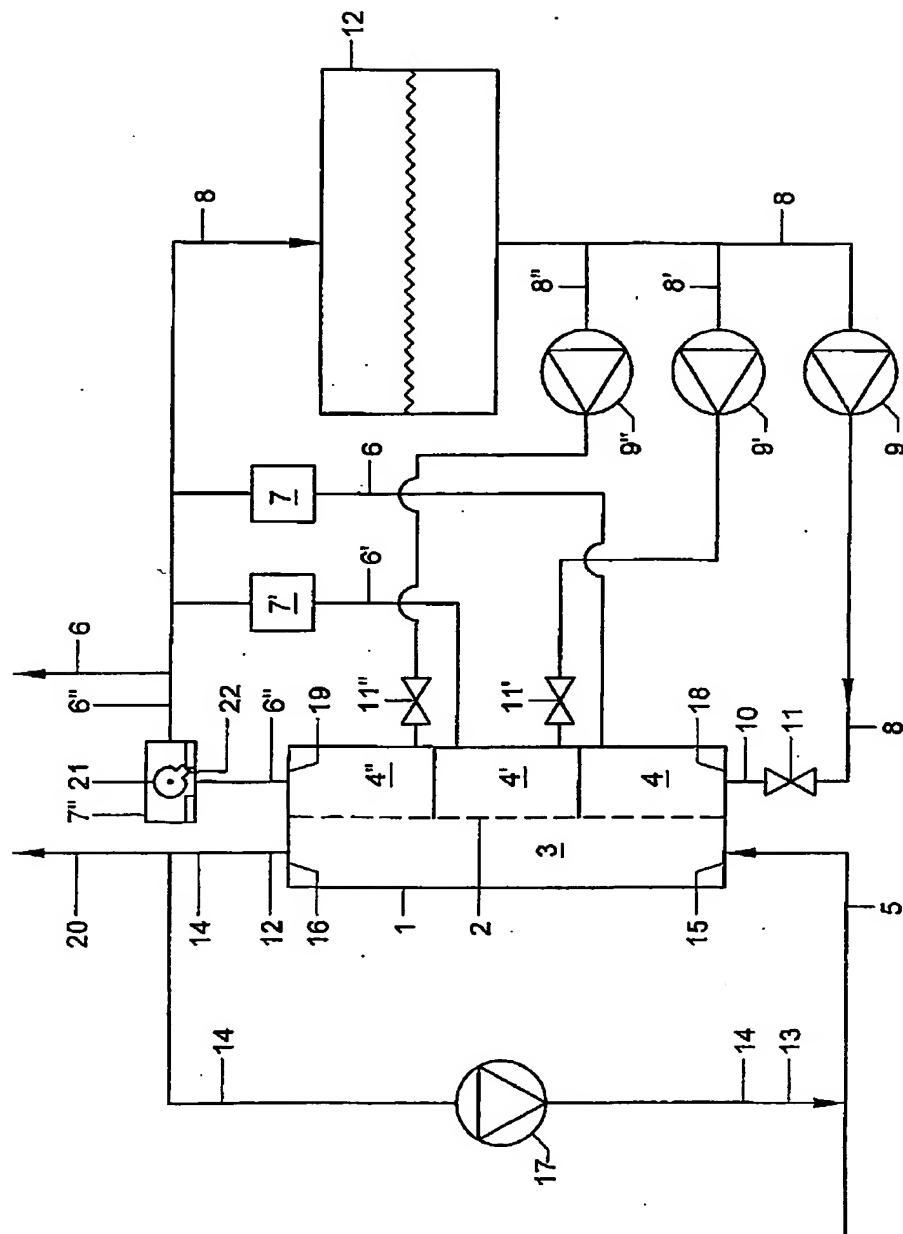


Fig. 3

INTERNATIONAL SEARCH REPORT

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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Date of the actual completion of the International search	Date of mailing of the International search report
9 May 2005	17/05/2005
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentbaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax. (+31-70) 340-3016	Authorized officer Hilt, D

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